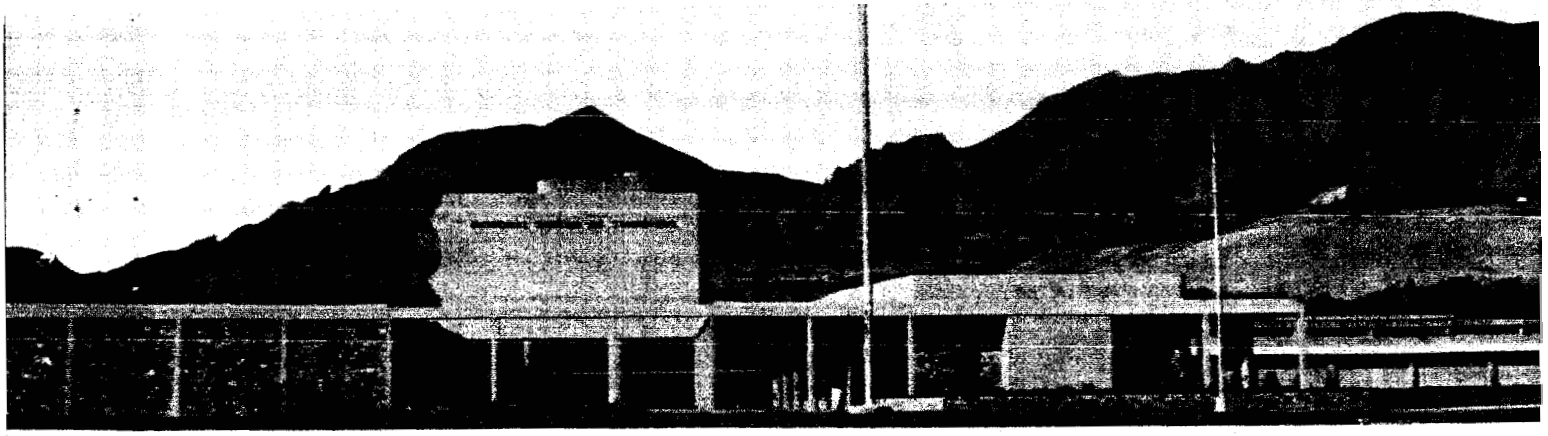

NBS REPORT
9254

SEMI-ANNUAL PROGRESS REPORT ON CRYOGENIC DATA CENTER ACTIVITIES FOR THE PERIOD OF JANUARY 1 THROUGH JUNE 30, 1966

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NATIONAL BUREAU OF STANDARDS
BOULDER LABORATORIES
Boulder, Colorado

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NATIONAL BUREAU OF STANDARDS REPORT

NBS REPORT 9254

June 30, 1966

SEMI-ANNUAL PROGRESS REPORT ON CRYOGENIC DATA CENTER ACTIVITIES FOR THE PERIOD OF JANUARY 1 THROUGH JUNE 30, 1966

V. J. Johnson
R. B. Stewart
N. A. Olien

INSTITUTE FOR MATERIALS RESEARCH

NBS PROJECT	SPONSORING AGENCY	CONTRACT DESIGNATION
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315-40-3150422	NASA	R-06-006-046

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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ABSTRACT

This semi-annual report summarizes activities of the Cryogenic Data Center for the first half of the 1966 calendar year. The introduction also outlines the scope of the Center's data compilation program and briefly describes the principle functions of the documentation program.

Progress of the data evaluation and compilation efforts on the following tasks is reported: 1) Thermodynamic Properties of Hydrogen in the Solid, Liquid, and Gaseous Phases from 4° to 300°K (this work includes consideration of the ortho-para and isotopic modifications); 2) Thermodynamic Properties of Oxygen (compilation work completed); 3) Thermodynamic Properties of Argon in the Solid, Liquid, and Vapor Phases from 20° to 300°K; 4) Saturation and Fixed Point Properties of Cryogenic Fluids for the Liquid-Vapor, Solid-Vapor, and Solid-Liquid Transitions; 5) Viscosity and Thermal Conductivity of Cryogenic Fluids; 6) Physical Equilibria and Thermodynamic and Transport Properties for Binary Mixtures of the Cryogenic Fluids. The status of a number of other tasks in progress is given. Included are sample T-S and P-Z charts for oxygen and sample tables of viscosity for oxygen and nitrogen.

The Documentation Unit reports that distribution of the Weekly Current Awareness Service has increased from about 350 copies per week to nearly 1000; that new assessions increased 47% over the previous period with 4348 items being processed in this six months period; and that there has been 73% increase in bibliographic searches with 38 major searches completed. During this period a total of 821 orders were filled with 5938 items, a 3% increase over the previous period.

The report includes a summary chart for the status of data compilation tasks, a list of thermodynamic charts that have been prepared and a list of 30 publications and reports issued by the Cryogenic Data Center.

Authors

SEMI-ANNUAL PROGRESS REPORT ON CRYOGENIC DATA CENTER ACTIVITIES FOR THE PERIOD OF JANUARY 1 THROUGH JUNE 30, 1966

V. J. Johnson, R. B. Stewart, N. A. Olien

1.0 INTRODUCTION

The Cryogenic Data Center is organized around two operational units: the Data Compilation Unit under the direction of R. B. Stewart and the Documentation Unit under N. A. Olien.

The Data Compilation Unit is working under the sponsorship of the National Aeronautics and Space Administration, currently under Contract R-06-006-046, which is designated as NBS Project 3150422. The Documentation Unit's basis of operation and development is supported from the Bureau's direct appropriation under Project 3150121. Some of the services of this unit are reimbursed from other projects and outside sales.

1.1 Scope and Outline of Data Compilation Activities.

The Cryogenic Data Compilation Unit is engaged in the critical evaluation and compilation of data on the properties (thermodynamic, transport, and other thermophysical properties) for the principal fluids (and common mixtures of these fluids) used at low temperatures, namely:

Helium	Nitrogen	Carbon Monoxide	Methane
Hydrogen	Oxygen	Fluorine	Xenon
Neon	Air	Argon	Krypton

The scope of the compilation program also includes the properties of metallic elements, selected alloys, and element dielectrics as follows:

Electrical Resistivity	Thermal Expansion
Dielectric Constant	Specific Heat
Thermal Conductivity	Enthalpy

Ultimately it is expected that data will be compiled for the mechanical properties of structural materials, however, it may be some time yet before tasks are started.

The thermodynamic properties of fluids being pursued are:

Pressure-Volume-Temperature
Vapor Pressure, Latent Heat, Saturation Densities
Isothermal Compressibility, Volume Expansivity
Entropy, Enthalpy, Internal Energy
Specific Heats (C_p, C_v, C_{sat})
Velocity of Sound

The transport properties of fluids included in the program are:

Thermal Conductivity	Diffusion Coefficients
Viscosity	Thermal Diffusion Coefficients
Prandtl Number	

Other thermophysical properties include:

Dielectric Constant, Refractive Index	Surface Tension
	Magnetic Properties
Dielectric Breakdown	Optical Properties
Electrical Resistivity	

The literature is monitored on a continuing basis for all phases of the above program. As specific tasks are undertaken, comprehensive bibliographies are prepared and sometimes published. Task notebooks are made for preliminary selection of data and, where feasible, preliminary data sheets are issued. Critical evaluation is done by the senior staff consisting of two physicists, one engineer (thermodynamic), chemist, and physical chemist. The staff collaborates with theoretical groups within NBS and with consultants for better development of the theory where pertinent. The Data Compilation Unit operates as part of the National Standard Reference Data Program.

1.2 Outline of Principle Documentation Activities

Literature Searching. An awareness of publications and reports of cryogenic interest is maintained by the regular review of a hundred or more periodicals subscribed to by the Data Center, by a weekly review of the "Current Contents" service, by reviewing some fifteen abstract journals, and by noting references in cryogenic documents. 150 to 200 items are noted weekly.

Literature Procurement. Published literature is obtained from local, national, and foreign libraries. A sizable portion is obtained on microfiche from the Technical Library at Delft, Holland. (The service from Delft is economical, fast, and quite comprehensive.) Report literature is procured mostly from the large national centers (NASA, DDC, and the Clearinghouse). Many new reports are obtained directly from the corporate

source as a part of the Data Center's program of information exchange.

Cataloging, Coding, and Machine Processing. In addition to standard library cataloging of pertinent literature selected for the system, it is coded into nine main subject categories such as properties of solids and of fluids, cryogenic processes and equipment, instrumentation and laboratory apparatus, cryogenic techniques, etc. Further characteristic coding is then assigned as to the type of document, temperature range, type and range of the data, etc. This is followed by comprehensive subject coding based on the Data Center's thesaurus or dictionary of terms.

Bibliographic Storage and Retrieval. All cataloging and coding is converted to machine readable form for automated processing on the Boulder Laboratories' Control Data Corporation 3600 computer. The principal programs used are for searching, dictionary term identification, and for catalog tape output. Smaller programs are also in use for additional indexing, tape updating, corrections, etc. Custom bibliographies are prepared for specific subjects or for broad subject areas. Indexing follows from the nature of search queries and can be quite detailed. An average of 1 or 2 major searches are made each week plus a number of small ones for answers to single questions.

Distribution of Literature and Data. Announcements and abstract cards of new literature evolving from the Cryogenic Laboratory's Research Program are sent to nearly 3000 persons and institutions periodically. Nearly five hundred separate items of literature are now available. Fifteen to twenty thousand documents a year are distributed in response to some two thousand orders. Plans are underway with the Clearinghouse to take over much of this distribution.

2.0 ACTIVITIES OF THE DATA COMPILATION UNIT DURING THIS REPORTING PERIOD

[Report on Tasks under NASA Contract R-06-006-046 (NBS Project 3150422)]

The emphasis during the reporting period has been on the compilation of the thermodynamic properties of oxygen and on the compilation of the transport properties of cryogenic fluids.

A part of the funding on these tasks was from NASA MSFC Government Order H-76797; this project terminated on January 15, 1966 and was reported in "Cryogenic Propellant Fluid Properties, Final Report for Data Evaluation Program on Government Order H-76797," NBS Report 9198 (February 1, 1966). The current NASA Contract (R-06-006-046) provides funds for the period December 1, 1965 through October 31, 1966. This series of consolidated project reports on the Cryogenic Data Center Activities, however, covers the periods of the calendar year rather than the individual contract year.

The scope of work for the current calendar year includes the following tasks:

1. Thermodynamic properties of hydrogen in the solid, liquid, and gaseous phases from 4° to 300°K. (This work includes consideration of the ortho-para and isotopic modifications.)
2. Thermodynamic properties of oxygen.
3. Thermodynamic properties of argon in the solid, liquid, and vapor phases from 20° to 300°K.
4. Saturation and fixed point properties of cryogenic fluids for the liquid-vapor, solid-vapor, and solid-liquid transitions.
5. Viscosity and thermal conductivity of cryogenic fluids.
6. Physical equilibria and thermodynamic and transport properties for binary mixtures of the cryogenic fluids.

Progress on the above tasks from one reporting period to another varies with the emphasis given. Most of these tasks are continuations from the previous year's activities, and some of these need to be continued beyond the current year. Additional tasks which will be undertaken as the above tasks are completed and as work assignments will allow are as follows:

1. Thermodynamic properties of fluorine.
2. Thermodynamic properties of air.
3. Thermodynamic properties of methane.
4. Dielectric constant of cryogenic fluids.
5. Surface tension of cryogenic fluids.

A continuing effort is made in the survey of current literature, searching of the older literature, and the acquisition of all documents of interest to the data compilation program. The present holdings in the literature file for this project exceed 7000 documents. Additional items are now being procured, coded, and cataloged at the rate of approximately 50 per week. In addition to the acquisition and cataloging of literature, data sheets are prepared in work notebooks to provide the Unit with ready access to the available data on a broad range of topics. This not only provides the information needed for future tasks but also provides information needed to make the Cryogenic Data Center an information source on the thermophysical properties for cryogenic materials.

A review of progress on the current tasks for the present reporting period follows.

2.1 Thermodynamic Properties of Hydrogen

The task for extending the thermodynamic property tables for hydrogen has been inactive during the current reporting period. However, with the completion of the oxygen compilation this task will be emphasized during the next period. In addition to the evaluation of the hydrogen data from the literature, the study of temperature scales used by the various laboratories which have reported experimental data of interest will be completed. The objective of this study of temperature scales is to allow conversions to the thermodynamic scales for the data from the various laboratories.

At the request of the NASA Project Manager, a task for the construction of an enlarged T-S diagram for liquid parahydrogen has been undertaken. This chart will use the data from NBS Monograph 94 and will include properties for liquid from the triple point to 55°R with pressures to 100 psia, and will include liquid-vapor mixture values for qualities to 0.1 percent vapor (by weight).

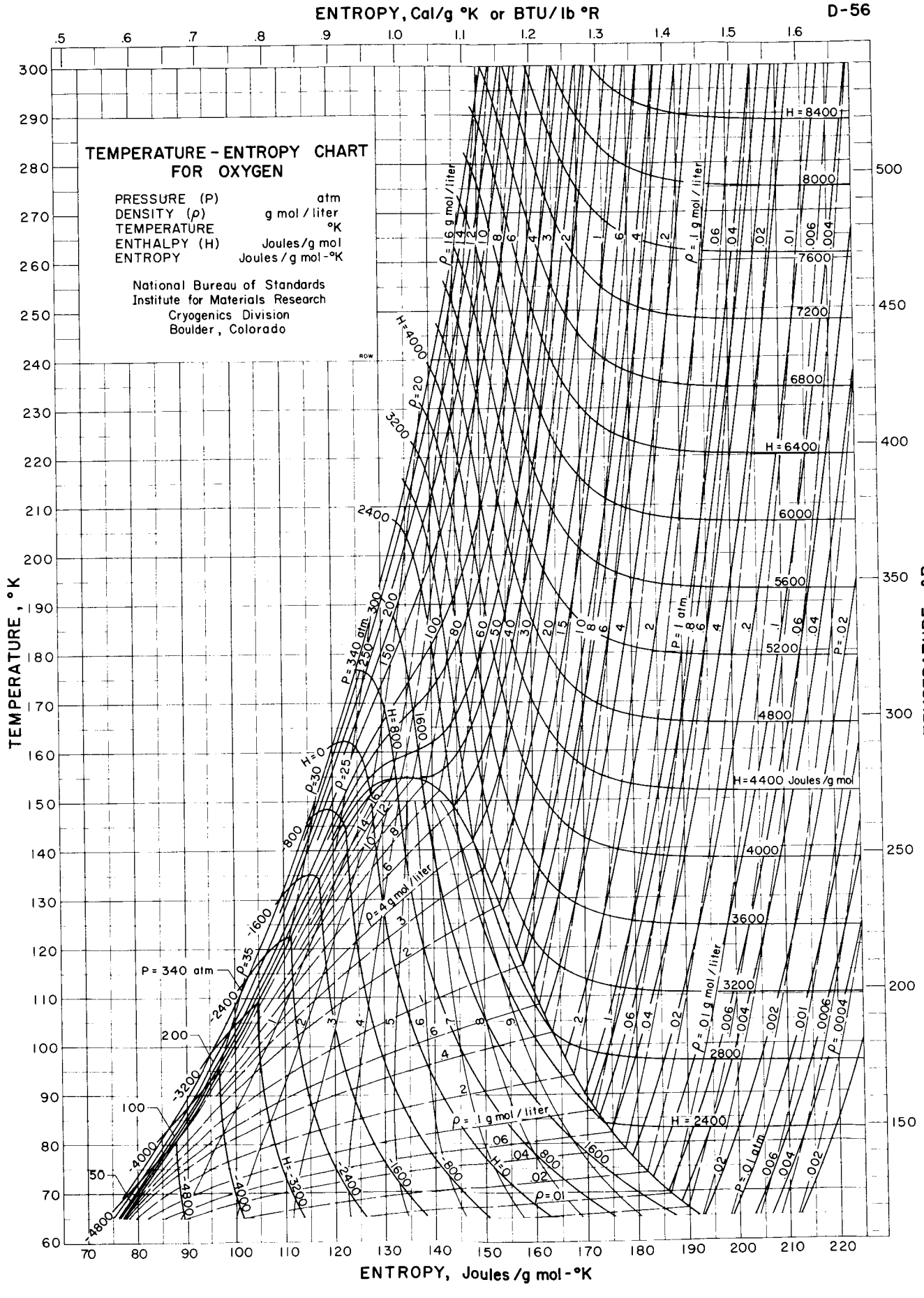
During this reporting period a task for the compilation of the thermodynamic properties of normal deuterium has been undertaken. This work is being done by a graduate student as a thesis project under the supervision of the project leader. It is anticipated that this compilation will be completed within the next three months.

2.2 Thermodynamic Properties of Oxygen

The compilation of thermodynamic properties of oxygen has been completed and new tables and T-S and P-Z diagrams are now available. This compilation is based on new P-V-T data from the oxygen properties measurement program in this laboratory, together with the P-V-T and other thermodynamic property measurements from the literature. The complete analysis of the new NBS data has not been completed by the experimenter, and some additional measurements will be made, primarily for the low temperature liquid. However, in this compilation these new data have been compared with other data in the published literature, and estimates of the uncertainties of the P-V-T values calculated by the equation of state have been determined. The new compilation of oxygen thermodynamic properties is available as "The Thermodynamic Properties of Oxygen," by Richard B. Stewart, Ph.D. Dissertation, University of Iowa (June 1966)[28]. Copies of the T-S and P-Z diagrams are reprinted on the following pages. Copies of the dissertation and separate copies of the diagrams ($8\frac{1}{2}$" x 11" and 17" x 22") may be obtained from the Cryogenic Data Center. An NBS publication of this compilation task will be issued after the experimental program is completed and the results published.

2.3 Thermodynamic Properties of Argon

The task on the thermodynamic properties of argon is assigned to Professor Gosman who is employed with the Cryogenic Data Center during the summers. This task was also the subject for his dissertation, "Thermodynamic Properties of Argon in the Liquid and Gaseous State for Temperatures from the Triple Point to 300°K with Pressures to 1000 Atmospheres," University of Iowa (Aug. 1965)[30]. The dissertation included a recalculation of the thermodynamic property tables that were issued in NBS Report 8293[14]. The equation of state developed as a part of the dissertation has now been extended to the low pressure vapor region for vapor properties to temperatures down to 20°K. The equation of state has also been extended in the high density liquid range to the fusion line. During the summer, 1966, a manuscript will be developed which will present the results of this task together with extensive tables and diagrams for the properties of argon.



Reprinted from: "The Thermodynamic Properties of Oxygen" by Richard B. Stewart, Ph.D. Dissertation, University of Iowa, Iowa City (June, 1960).

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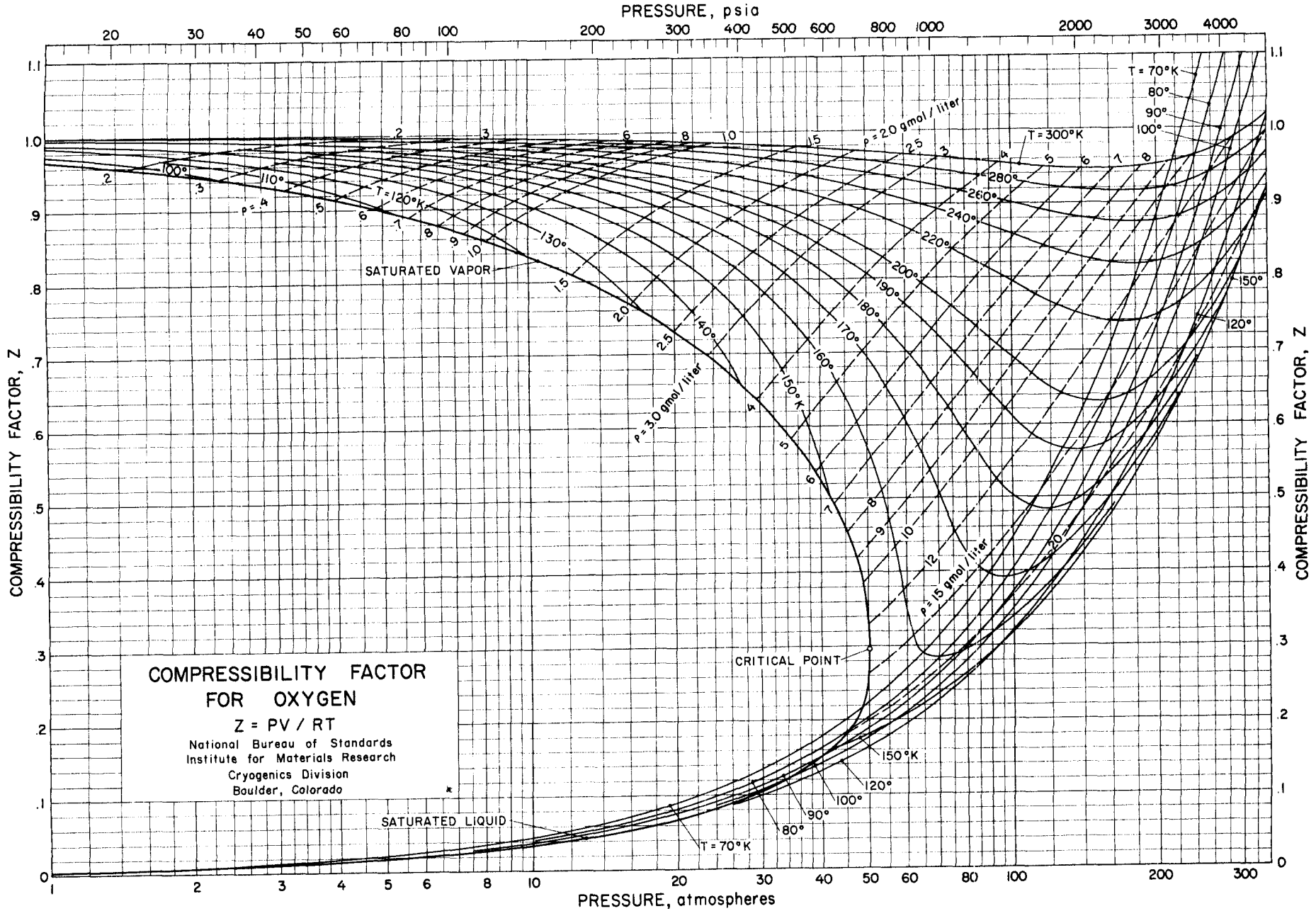

Reprinted from: "The Thermodynamic Properties of Oxygen" by Richard B. Stewart, Ph.D. Dissertation, University of Iowa, Iowa City (June, 1956).

NBS File No. D-6100

2.4 Saturation and Fixed Point Properties of Cryogenic Fluids for the Liquid-Vapor, Solid-Vapor, and Solid-Liquid Transitions

This task has been inactive during the current reporting period. It is anticipated that work on this task will be resumed as other compilation projects are completed.

2.5 Viscosity and Thermal Conductivity of Cryogenic Fluids

The task for the compilation of the transport properties of cryogenic fluids was undertaken early in 1965. A preliminary bibliography was obtained from the Cryogenic Data Center's Documentation Unit, and literature searches have been completed for the transport properties of argon, oxygen, nitrogen, neon, krypton, and xenon. Copies of all documents have been procured, and the numerical data and pertinent facts related to the data have been extracted and compiled on data sheets for task notebooks for these fluids. A literature search for helium is in progress and these data are being compiled in a task notebook.

A general survey of the theories of transport phenomena under different experimental conditions was also undertaken. The initial phase of this study was concerned with the simplest case, that of a non-quantum gas with spherically symmetrical force field. Argon was chosen for this initial study, and the Chapman-Enskog theory was applied to the viscosity, thermal conductivity, and the self-diffusion coefficients for argon. The best potential function was selected and the optimum potential parameter determined. This work is reported in publication [26]. Transport property data for dilute argon have been calculated and are published in [27]. A further result of this initial study was the development of a general method to determine the best intermolecular potential functions as a means of determining the optimum correlation of given sets of data for transport and thermodynamic data. A general method to investigate the relation between potential functions and macroscopic experimental data, such as transport coefficients or virial coefficients is in progress, and results have been obtained. This work will be in collaboration with Dr. Klein of NBS Washington. The procedure will be extended and published in the near future. This general method has been applied to the data for oxygen, nitrogen, neon, xenon, and krypton, and results for the viscosity coefficients of oxygen and nitrogen have been calculated. A preliminary table of these values is presented on the following pages. It is not possible to calculate thermal conductivity for oxygen and nitrogen from rigorous theory, but preliminary calculations have been obtained for the thermal conductivity from an empirical curve fitting.

The study of transport phenomena for the dense fluid was undertaken early in the current reporting period, and the compilation of transport phenomena of the cryogenic fluids has been extended to the dense fluids. A study of the many theories available led to the decision that the Enskog theory is best suited, at the present time, to correlate experimental transport data. Preliminary corresponding states calculations of the Enskog theory show promise. It appears that the rare gases can be correlated satisfactorily up to about 400 atmospheres. The Enskog theory is also being investigated theoretically. A very careful statistical investigation of transport second virial coefficients has also been started. These projects concerning the dense fluid are the results of close collaboration with Dr. J. V. Sengers of NBS Washington.

2.6 Physical Equilibria and Thermodynamic and Transport Properties for Binary Mixtures of the Cryogenic Fluids

This task has been inactive during the current reporting period, with the exception of the continued acquisition of literature on this subject. It is anticipated that work on this task will be resumed as staff become available.

2.7 Thermodynamic Properties of Methane

As a preliminary to undertaking an extensive compilation of the thermodynamic properties of methane, an extensive literature search and compilation of the bibliography on the thermophysical properties of methane has been undertaken. It is anticipated that this bibliography will be available in another six months.

VISCOSITY OF GASEOUS OXYGEN*

(PRELIMINARY TABLE)

TEMP K	VISCOSITY G/CM-SEC $\eta \times 10^6$	TEMP K	VISCOSITY G/CM-SEC $\eta \times 10^6$
		500	301.6
		510	305.8
		520	310.0
		530	314.1
		540	318.2
		550	322.1
		560	326.2
		570	330.2
		580	334.2
		590	338.0
100	76.7	600	341.9
110	84.2	610	345.8
120	91.7	620	349.6
130	99.1	630	353.4
140	106.4	640	357.2
150	113.5	650	360.9
160	120.6	660	364.7
170	127.6	670	368.3
180	134.4	680	372.0
190	141.0	690	375.6
200	147.5	700	379.1
210	154.0	710	382.8
220	160.3	720	386.3
230	166.5	730	389.8
240	172.6	740	393.3
250	178.5	750	396.8
260	184.3	760	400.3
270	190.1	770	403.8
280	195.8	780	407.2
290	201.3	790	410.7
300	206.7	800	414.1
310	212.1	810	417.5
320	217.4	820	420.9
330	222.6	830	424.3
340	227.7	840	427.6
350	232.9	850	431.0
360	237.9	860	434.3
370	242.8	870	437.7
380	247.7	880	441.0
390	252.5	890	444.2
400	257.2	900	447.3
410	261.9	910	450.5
420	266.5	920	453.8
430	271.1	930	457.0
440	275.6	940	460.2
450	280.0	950	463.4
460	284.4	960	466.5
470	288.8	970	469.6
480	293.1	980	472.8
490	297.3	990	475.9

* Calculated for the dilute gas by the Kihara potential, with $\gamma = .1$, $\sigma = 3.38$ Å, $\epsilon/k = 124.5$°K.

VISCOSITY OF GASEOUS NITROGEN*

(PRELIMINARY TABLE)

TEMP K	VISCOSITY G/CM-SEC $\eta \times 10^6$	TEMP K	VISCOSITY G/CM-SEC $\eta \times 10^6$
		500	256.4
		510	259.8
		520	263.3
		530	266.6
		540	270.0
		550	273.3
		560	276.6
		570	279.9
		580	283.1
		590	286.4
100	69.3	600	289.5
110	75.8	610	292.7
120	82.2	620	295.8
130	88.5	630	299.0
140	94.7	640	302.1
150	100.7	650	305.0
160	106.7	660	308.0
170	112.4	670	311.1
180	118.1	680	314.1
190	123.7	690	317.1
200	129.2	700	320.0
210	134.5	710	323.0
220	139.8	720	325.9
230	144.9	730	328.8
240	149.9	740	331.7
250	154.8	750	334.6
260	159.7	760	337.5
270	164.4	770	340.3
280	169.1	780	343.2
290	173.7	790	346.0
300	178.2	800	348.8
310	182.7	810	351.6
320	187.1	820	354.4
330	191.4	830	357.1
340	195.6	840	359.8
350	199.8	850	362.5
360	203.9	860	365.1
370	207.9	870	367.9
380	211.9	880	370.6
390	215.8	890	373.3
400	219.7	900	375.9
410	223.6	910	378.5
420	227.4	920	381.2
430	231.2	930	383.8
440	234.9	940	386.4
450	238.6	950	389.0
460	242.2	960	391.6
470	245.8	970	394.2
480	249.4	980	396.7
490	252.9	990	399.3

* Calculated for the dilute gas by the Kihara potential, with $\gamma = .2$, $\sigma = 3.55$ Å, $\epsilon/k = 116.7$°K.

3.0 ACTIVITIES OF THE DOCUMENTATION UNIT DURING THIS REPORTING PERIOD (NBS PROJECT 3150121)

Progress is reported on the following documentation activities: Current Awareness Service, entry of new material into the information storage and retrieval system, literature searching and bibliography preparation, and announcement and distribution of NBS Cryogenics Division publications.

3.1 Current Awareness Service

This service was started in March of 1964 in response to suggestions from staff members and outside associates that literature being reviewed for input into the Center's storage and retrieval system may be of wide current interest. The Service, which is a "fall-out" from the basic operation of the Center, has been well received by the scientists and engineers of the cryogenic community. At the beginning of this reporting period (January 1966) twenty-eight new subscriptions were added to the list of some 92 periodicals previously received in the Data Center. In addition to this, forty-nine journals received by the Boulder Laboratories Library are reviewed cover-to-cover on a regular basis. The new periodicals involved were selected on the basis of the amount of low temperature information selected from them during the previous eighteen months. Subscription price versus yield was the determining factor in deciding whether to subscribe or to rely on the library subscription. The result of the increased coverage has been a substantial rise in the number of items listed each week, so much so that work has been done on developing an index. Permuted title indexes were prepared for list no. 107 and list no. 113, but problems with scheduling time on the computer and other handling difficulties forced us to drop this as a regular index. Starting with list no. 111 each list has been divided into three sections: 1) Low Temperature Physics and Chemistry, 2) Cryogenic Engineering, 3) Miscellaneous. A small subject index for each of the first two sections was begun with list no. 115 and we plan to continue the subject index on a regular basis. In June a concerted effort was started to publicize the availability of the Current Awareness Service. As a result the distribution of the list has been increased from about 350 per week to nearly 1000 per week. It is presently being sent to anyone requesting it, but it is expected that a nominal charge will soon have to be instituted to cover the cost of printing and mailing. The printing and mailing are now done by the Government Printing Office in Denver rather than by our own local shop as in the past. This has made possible an improved format, speedier service, and less work for the Data Center personnel.

3.2 Bibliographic Storage and Retrieval System

Continued progress has been made in obtaining a larger percentage of the material processed into the system in full copy form rather than in abstract form. Over 85% of the new entries are from full copy and complete documents have been received for a number of the older entries processed from abstracts. Processing some accessions from abstracts is necessary, however, and in some instances preferable. For example, abstracts of certain Russian papers, most East European papers, and all Chinese papers contain more useable information for the coder than do the original articles. Continued emphasis is being placed on procurement of literature in microform. 45% is now obtained as microfiche. Convenience of handling and savings in file space are main advantages as well as cost of the documents. Reproduction for others is also cheaper but very little of this has been done as yet since good readers are not readily available to many people.

Improvements have been made in the cataloging operation. A comprehensive and detailed instruction for use of the clerical personnel in processing documents was prepared [29]. This instruction has proved quite useful in improving cataloging consistency, aiding in the training of new personnel, and reducing the time spent answering questions.

In January 1966 the categories covering cryogenic equipment and instrumentation and laboratory apparatus became operational to the extent that new material entering the system is being fully processed for mechanized retrieval. It is now possible to conduct limited searches in these

areas. A large group of patents were processed during this reporting period also. As of June 30, 1966 the status of the various categories of cryogenic information was as follows:

a) Properties of materials - 15,200 references available for search,

b) Cryogenic processes and equipment - 3500 references available for search,

c) Instrumentation and laboratory apparatus - 800 references available for search.

These three areas represent approximately 85% of the new material being entered into the system, therefore, nearly all documents being processed will become available for machine search. Total accessions now stand at 36,770.

Previous progress reports have stated that the entire citation for all new entries is key-punched into cards and placed on magnetic tape. During this reporting period computer programs were written to identify and select from this tape the following information: 1) all authors with a code to indicate first author, 2) author affiliation for published literature, 3) corporate source for report literature, 4) journal citation. Each of these items is coded so that machine sorting can be performed and separate indexes established. Within the next few months we plan to compile these indexes and begin incorporating them with some additional indexing with which we have been experimenting. These additional indexes will increase our search capability and speed up duplicate searching of our existing file.

3.3 Literature Searches and Bibliography Preparation

It is reasonable to expect that an increase in the circulation of the Current Awareness Service would result in a larger demand for literature searches. This has indeed been the case, since a sharp increase in search requests was noticed shortly after the first of the calendar year. The information system, particularly in the area of the properties of materials, has been building a resource of searchable information for a number of years. Mechanization also has grown to the point that it is now possible to prepare bibliographies at a much faster rate than previously. It seems appropriate that efforts be made to expand the bibliographic services of the Data Center at this time. In addition to the above, we have initiated efforts to announce the services of the Documentation Unit through scientific and technical journals. In this light, contacts have been made with the American Institute of Physics and with the publishers of Cryogenic Engineering News.

3.4 Announcement and Distribution of NBS-Cryogenics Division Publications

During this reporting period the Cryogenic Data Center's mailing list was compared with the "corporate source" authority list and any missing corporations were added. This was done to aid in the development of a simplified system of recording document distribution. Distribution statistics and use of the Data Center Services are frequently requested by various management groups.

At the end of this reporting period arrangements are well underway for the Clearinghouse for Federal Scientific and Technical Information (Springfield, Va., 22151) to take over the sale and distribution of reprints, reports, thermodynamic charts, and other such items generated in the Cryogenics Division of NBS. Announcement of new publications and distribution of abstract cards will still be done by the Data Center. The Clearinghouse is specifically designed for government document distribution and will relieve the Data Center of a burdensome job. The inventory alone (of some 80,000 items for nearly 500 separate documents) was becoming a real problem.

An announcement of 20 new publications with abstract cards was mailed to the 2800 persons and firms on the Data Center's mailing list. A list of 33 translations available from the Data Center was also included. 821 orders were filled with a total of 5938 items.

Summary of Documentation Unit Activities

1) Current Awareness Service
   a) Coverage - 136 items per list - 18% increase.*
   b) Circulation - 473 addressees - 83% increase.*

*Compared with rate indicated in the Fourth Quarterly Progress Report (NBS Report 9156, December 1965).

2) Entries into information storage and retrieval system - 4348 new documents - 47% increase.

3) Literature searches and bibliography preparation
   a) 38 major searches - 73% increase.
   b) The distribution to the requestors is as follows: 16 for Cryogenics Division staff, 13 for private industry, 6 for other government agencies, 5 for non-profit research institutes.

4) Distribution of Cryogenics Division publications - 821 orders filled with 5938 items - 3% increase.

4.0 SUMMARY CHART OF DATA COMPILATION TASKS (NBS Project 3150422)

TASK NUMBER	DATA COMPILATION TASK	ANTICIPATED STARTING DATE	DATE TASK WAS INITIATED	PRELIMINARY BIBLIOGRAPHY COMPILED FROM CDC FILES	DATE INITIATED OR PERCENT COMPLETED							REPORT IN EDITORIAL REVIEW OR IN PRESS (Date)	PROPERTY DIAGRAMS (Numbers refer to references listed in Section 5.0)	PUBLICATIONS (Numbers refer to references listed in Section 6.0)	ESTIMATED COMPLETION DATE	TASK INACTIVE (Date)	TASK COMPLETED (Date)
					LITERATURE SEARCH	LITERATURE PROCUREMENT (As listed in bibliography)	BIBLIOGRAPHY COMPILATION	DATA EXTRACTION AND ORGANIZATION	DATA ANALYSIS AND CORRELATION	DATA PREDICTIONS AND EXTENSIONS	REPORT PREPARATION						
1	Thermodynamic Properties of Normal and Para Hydrogen		1/64	1/64	95%	95%	95%	85%					D-20,20A,20B 21A,21B,22 22A,22B	19,22,25	6/67		
2	Thermodynamic Properties of Oxygen		1962		100%	100%	100%	100%	100%	100%	6/66		D56,57	2,10†,15,23,25,28			6/66
3	Thermodynamic Properties of Argon		1963		100%	100%	100%	100%	100%	100%	6/66			13,14	10/66		
4	Saturation and Fixed Point Properties of Cryogenic Fluids		1962			100%	100%	80%	10%					8,23		4/65	
5	Viscosity and Thermal Conductivity of Cryogenic Fluids		4/65	4/65	90%	90%	90%	75%	50%					6,26,27			
6	Physical Equilibria and Thermodynamic and Transport Properties for Binary Mixtures of the Cryogenic Fluids	6/67															
7	Thermodynamic Properties of Fluorine	6/67												5			
8	Thermodynamic Properties of Air	6/67															
9	Thermodynamic Properties of Methane		5/66	3/66	80%	60%	40%							12			
10	Dielectric Constant of Cryogenic Fluids	10/66												4			
11	Surface Tension of Cryogenic Fluids	10/66															

†Superseded by later publication

5.0 THERMODYNAMIC PROPERTY CHARTS*

Fluid	Number†	Coordinates	Range	Data Source††	Date Issued
Helium	D-3	T-S	20 to 300°K, 0.1 to 100 atm	[1]	June 1961
	D-52	T-S	15 to 300°K, 0.1 to 100 atm	NBS Tech Note 154	Jan. 1964
	D-53	T-S	3 to 25°K, 0.5 to 100 atm	"	"
	D-54	H-S	3 to 25°K, 1.0 to 100 atm	"	"
	D-13	P-Z	20 to 300°K, 1.0 to 100 atm	[1]	Feb. 1961
Parahydrogen	D-20A‡	T-S	20 to 100°K, 1.0 to 340 atm	NBS Tech Note 130	Dec. 1961
	D-21A	T-S	80 to 300°K, 1.0 to 100 atm	"	"
	D-22A‡	H-S	20 to 60°K, 1.0 to 340 atm	"	"
(British units)	D-20B‡	T-S	36 to 180°R, 10 to 5000 psia	"	"
"	D-21B	T-S	140 to 540°R, 10 to 1500 psia	"	"
"	D-22B‡	H-S	36 to 112°R, 10 to 5000 psia	"	"
	D-20	T-S	14 to 100°K, 0.1 to 340 atm	NBS Monograph 94	Aug. 1965
	D-22	H-S	16 to 64°K, 0.3 to 340 atm	"	"
	‡‡	T-S	35 to 60°R, 12.5 to 187.5 psia	NBS Report 8883	Sept 1965
Normal Hydrogen	D-14	P-Z	16 to 300°K, .08 to 800 atm	WADD TR 60-56**	Jan. 1961
	D-4	T-S	0 to 150°K, 0.6 to 300 atm	NBS - RP 1932	1948
	D-5	T-S	130 to 300°K, 0.8 to 600 atm	"	"
	D-28	T-S	280 to 600°K, 1.0 to 1200 atm	"	"
Neon	D-48-R	T-S	60 to 300°K, 0.1 to 200 atm	[16]	Mar. 1965
	D-49-R	T-S	25 to 80°K, 0.1 to 200 atm	[16]	"
	D-44	P-Z	30 to 300°K, 1.0 to 200 atm	[3]	Sept 1962
Nitrogen	D-23	T-S	65 to 300°K, 0.1 to 200 atm	NBS Tech Note 129	Jan. 1963
	D-16	P-Z	90 to 300°K, 1.0 to 500 atm	WADD TR 60-56**	Nov. 1960
	D-17	P-Z	90 to 300°K, 300 to 3000 atm	"	"
Oxygen	D-45	T-S	54 to 100°K, sat. liquid to 200 atm (liquid phase only)	NBS Report 7671	Jan. 1963
	‡‡	T-S	155 to 280°R, 10 to 725 psia	NBS Report 8883	Sept 1965
Air	D-18A	P-Z	90 to 300°K, 1.0 to 600 atm	WADD TR 60-56**	Oct. 1960
	D-18B	T-Z	75 to 300°K, 1.0 to 1000 atm	"	"
Carbon Monoxide	D-51	T-S	70 to 300°K, 0.1 to 300 atm	[11]	Sept 1963
	D-50	P-Z	100 to 300°K, 1.0 to 300 atm	[11]	"

* Unless otherwise noted, charts are in metric units.

† May be ordered from the Cryogenic Data Center, NBS, Boulder by this number. Both 8-1/2 x 11" and 17" x 22" sizes available at 10¢ and 25¢ each, respectively.

‡ Superseded by D-20 or D-22.

** "A Compendium of the Properties of Materials at Low Temperatures (Phase II)", WADD Technical Report 60-56, Part IV, R. B. Stewart and V. J. Johnson, General Editors (Dec. 1961).

†† Numbers in brackets refer to references listed in Section 8.0.

‡‡ Charts are for the liquid-vapor mixtures only. Not issued separately from NBS Report 8883.

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